The modern mammal fauna of Riversleigh and Boodjamullah National Park

Arthur W. White[1] and the late D. R Mason[2]

[1] Biosphere Environmental Consultants, 69 Bestic Street, Rockdale NSW 2216
1arthur@tpg.com.au
[2] Queensland Parks and Wildlife Service, PO Box 2316 Mt Isa, Queensland 4825

ABSTRACT

Extensive mammal surveys were carried out between 1998 and 2004 in the Riversleigh World Heritage Area and the Boodjamullah National Park in north-western Queensland. Thirty eight native mammal species were detected including a species (Spectacled Hare Wallaby) not recorded in the area for more than 80 years; the tally included 14 species of marsupial and 14 species of bat. Small terrestrial mammals were scarce and not detected each year. Six feral mammal species were also found. The relatively low density and diversity of small terrestrial mammals in the study area is similar to that reported elsewhere northern Australia (e.g. Woinarski *et al*. 2001.) and may be consistent with a pattern of general decline of native mammals in this region (Burbidge and McKenzie 1989, Kutt *et al*. 2005).

Key words: Mammals, mammal decline, wildlife survey, north-western Queensland.

Introduction

Australia's environmental history following European settlement has been characterized by a high extinction rate of native mammals. Species have been lost as a result of hunting, introduced predators, disease, land clearing and habitat changes (Burbidge and McKenzie 1989, Dovers 2000, Woinarski *et al.* 2004, Price *et al.* 2005). High extinction rates have been recorded in the south-eastern and south-western temperate regions of Australia; these regions have undergone the extensive habitat modification associated with the spread of agriculture (Woinarski and Braithwaite 1990). Some regions, such as monsoonal northern Australia, have been less impacted by agriculture and mammal extinctions have either not occurred there or have been minimal (Woinarski and Braithwaite 1990). However, mammal declines have been most severe in arid central Australia in areas unaffected by agriculture (Burbidge and McKenzie 1989).

While mammal extinctions have not been reported from northern Australia, recent reports have noted changes in the distribution of native fauna. Franklin (1990) observed that many species of granivorous birds in northern Australia were in decline. Braithwaite and Muller (1997) reported extensive declines in mammal abundance in the Kakadu National Park and this was validated by Woinarski *et al.* (2001) who undertook a detailed quadrat survey to test whether this decline was in response to poor wet season rainfall or was in response to some unrecognized factor. They found that many mammal species were in decline while others were not, despite a return of good wet season rainfall over a number of years; the cause of the decline in the affected species was not clear. There is clearly a need for a thorough assessment of the current status of mammal faunas in a range of sites across northern Australia.

Riversleigh (Miyumba National Park) and Boodjamullah National Park comprise 380,000 ha of tropical savanna and riparian gallery rainforest in the northwestern corner of Queensland. The majority of the land area has never been tilled or cleared for agriculture but has a long history of Aboriginal hunting and subsistence (Queensland Dept. of Primary Industries 1974). Grazing by cattle and feral herbivores has taken place around the periphery of the national parks. Recent mammal surveys are scant (e.g. Trainor *et al.* 1998) but there are historic records describing the diversity of mammals dating back to the late 1800s (for example Collett 1885; see Kirkpatrick and Lavery 1979). A wide range of marsupials and native rodents potentially occur in the area (Van Dyck and Strahan 2008). Unfortunately, there have been few repeated, systematic surveys and so changes in the diversity and abundance of the local mammal fauna are likely to go unnoticed.

In 1998, opportunistic fauna surveys were commenced (White 2003), initially at Riversleigh but later extended to Boodjamullah National Park. These surveys were started as part of the Riversleigh Project and were aimed at cataloguing the modern fauna of a region that is probably best-known for its fossil fauna (Archer *et al.* 1991).

The fauna survey included a range of mammal survey techniques and extended from 1998 to 2004. In 2001, the Queensland Environment Protection Authority commenced ground fauna surveys in the western section of the Boodjamulla National Park at Musselbrook as well as assisting with pit-trapping and Elliott trapping in the eastern sections of the park. The combined results of these mammal survey activities are presented herein as are the mammal assemblages noted in owl pellets and sub-fossil cave deposits from the local area.

Methods

Survey Area

Boodjamulla National Park is located about 350 kilometres northwest of Mount Isa in northwestern Queensland and borders the Northern Territory (Figure 1). The national park is approximately 380,000 ha in area and includes the World Heritage-listed Riversleigh fossil precinct as well as several small resource reserves. Boodjamulla is a diverse landscape that has few vehicle tracks or walking tracks. Lowland floodplains are dominated by eucalypt savanna with a *Triodia* ground layer (Cummings *et al.* 1998). The centre of the park encloses two major geological units; in the south-eastern corner the park parts of the Carl Creek Limestone member which includes heavily eroded and dissected limestone plateau, and in the central and northern section red sandstone escarpments associated with the Constance and Edith Ranges.

The vegetation assemblages in the area generally fall into four broad types (Bean 1991):

1. Gallery Rainforest (Figure 2); narrow bands of rainforest dominated by tall Paperbarks *Melaleuca leucadendra*, Leichhardt's Tree *Nauclea orientalis*, Cabbage Palm *Livistona mariae* and Pandanus *Panadanus aquaticus*. The gallery rainforest often exists as a green strip on either bank of the larger rivers and creeks in the area.
2. Plains Open Woodland (Figure 3): away from the rivers, the rainforest quickly gives way to open woodland growing on the alluvial clay plains. The main trees present are Western Bloodwoods *Eucalyptus terminalis*, Cabbage Gum *E. cornutifolia*, Silver-leafed Box *E. pruinosa*, Snappy Gum *E. leucophloia* and various species of low acacias. The ground cover is typically comprised of *Triodia* and other native grasses.

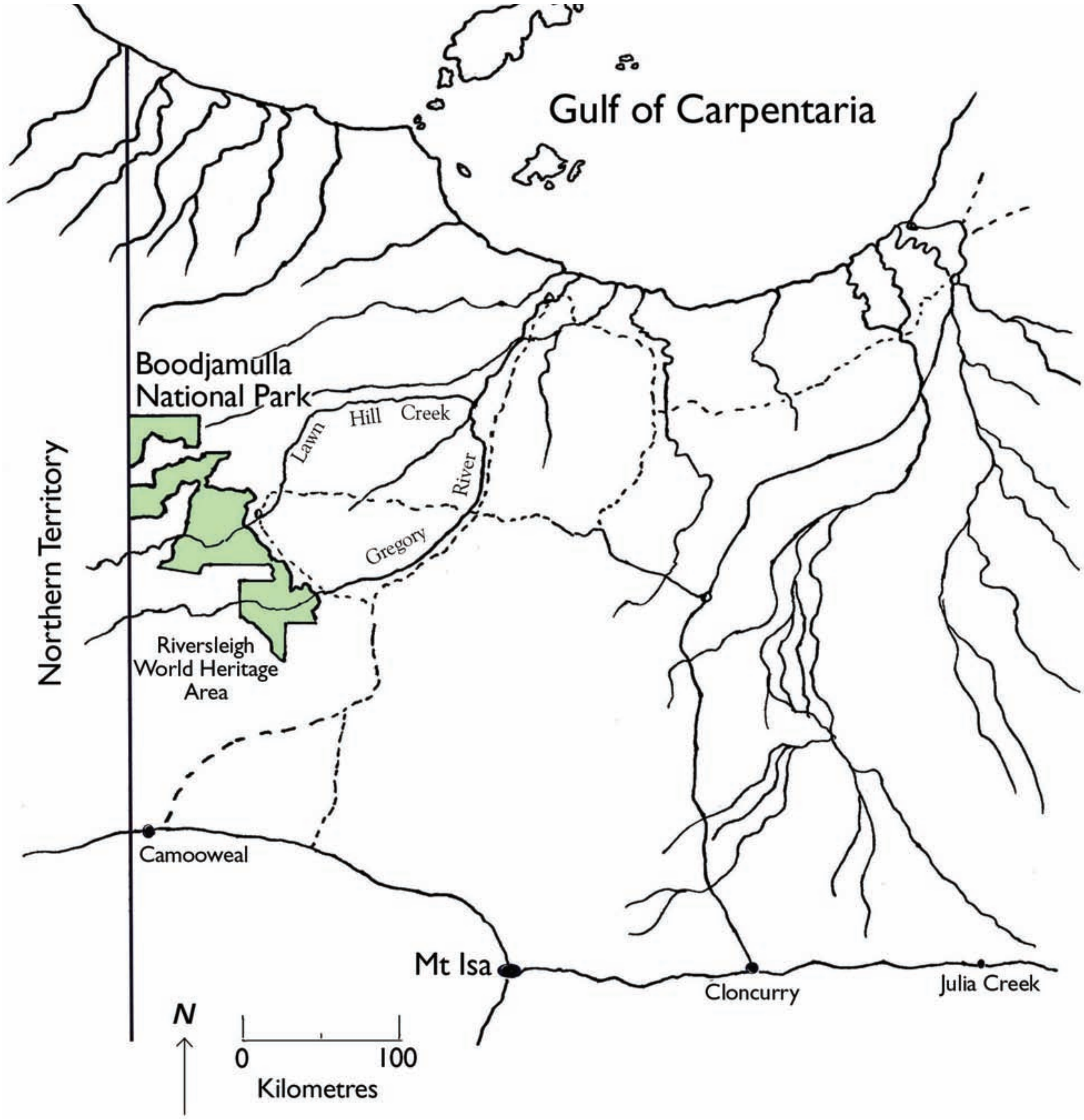

Figure 1. Riversleigh World Heritage Area and Boodjamullah National Park in north-western Queensland.

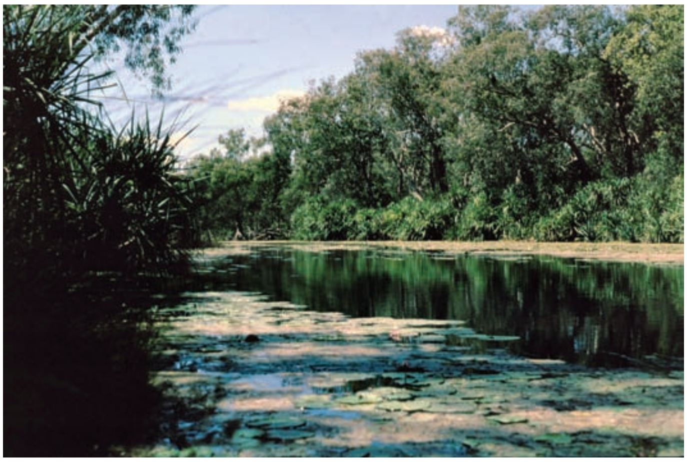

Figure 2. Gallery rainforest along the Gregory River, Riversleigh World Heritage Area. Photo, A. White.

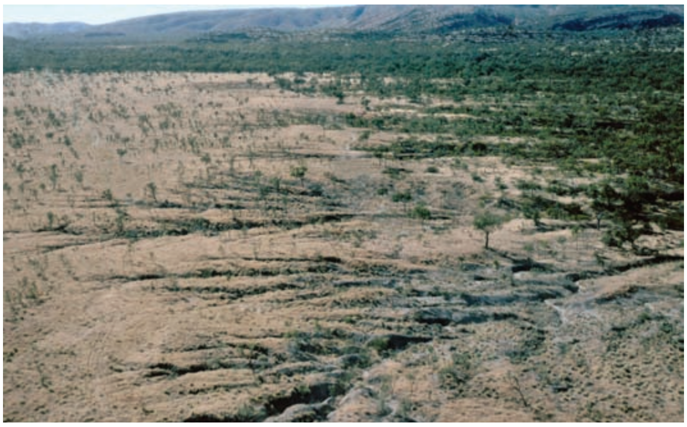

Figure 3. Plains Open woodland, Boodjamullah National Park. Photo, A. White.

3. Limestone Woodland (Figure 4): this sparse woodland consists of a heterogeneous mixture of trees that are able to tap the sparse water reserves in the limestone plateaux. Stunted *Alphitonia* and *Acacia* are present on the more exposed areas of limestone whereas Kurrajongs *Brachychiton collinus* and Figs *Ficus platynoda* and *F. coronata* grow in deep fissures and sink holes. Clumps of spinifex *Triodia pungens* and *T. longiceps* grow wherever there is enough soil to support them.

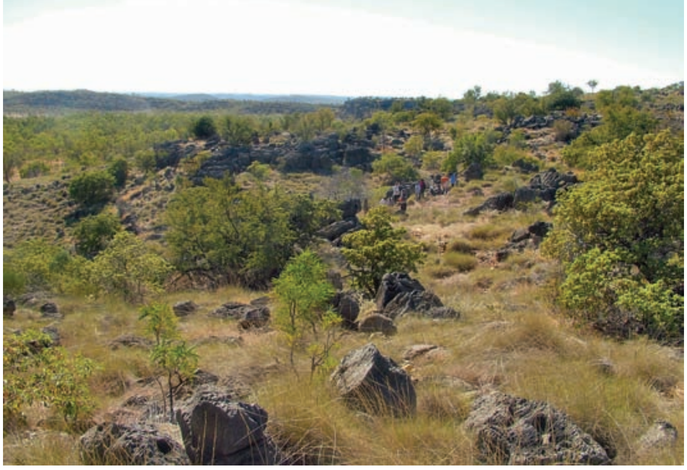

Figure 4. Limestone woodland, Riversleigh World Heritage Area. Photo, A. White.

4. Sandstone Woodland (Figure 5): sparse woodland dominated by Brittle Bloodwood *Eucalyptus aspersa*, Snappy Gum *E. leucophloia*, *Terminalia aridicola* and Emu Apple *Owenia acidula*. Unlike the limestone woodland, the understorey of sandstone woodland is dense and diverse and contains a variety of tall shrubs, mostly species of *Grevillea*, *Acacia* and *Calytrix*.

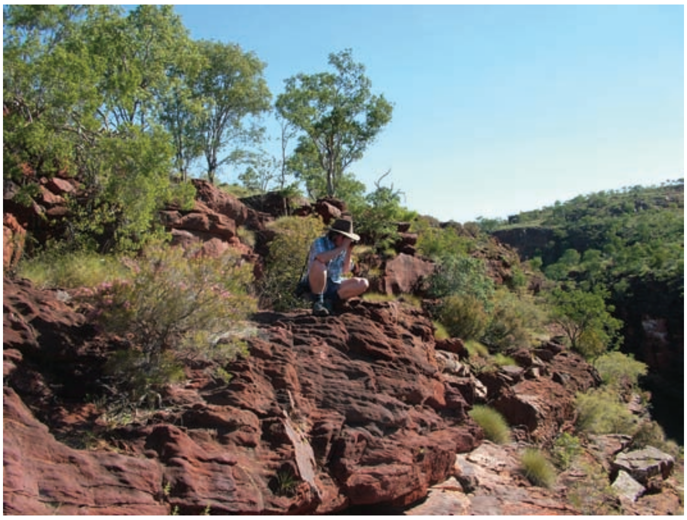

Figure 5. Sandstone woodland, Island Stack, Boodjamullah National Park. Photo, A. White.

Survey Sites

The size and general inaccessibility of land in the park confined the survey to three sectors of the park; the southern area comprising the Riversleigh World Heritage Area, the central area of Boodjamullah National Park including Louie Creek and its floodplain, Adels Grove and Lawn Hill Gorge and Lawn Hill Creek, and the western area including Musselbrook and Musselbrook Creek. Table 1 lists the number of sites surveyed in each area, and Figure 1 depicts the location of Elliott trap sites, which were the foci for other survey methods to follow.

Surveys were carried out in the southern and central area annually between 1998 to 2004. Most survey sites were only sampled once while others were repeatedly sampled. Surveys were only carried out once at each site in the western area in 2003 and 2004. Table 2 lists the survey dates for each survey period in each sector.

Survey techniques

The fauna survey utilized several commonly used survey methods based on trapping or observations of mammals. The main methods used were:

Elliott Traps: Elliott traps (A size) were set out in transects comprising 25 traps spaced at 10 metre intervals. Traps were left in place for five days (four nights) and were checked each morning and again in the late afternoon. Each trap was baited using balls of oatmeal, honey, vegemite and peanut butter. Each trap also contained a wad of spinifex for nesting material. Each site was only trapped once.

Table 1. Number of Survey Sites in each Sector of Riversleigh and Boodjamullah.

Type of Survey	Southern Sector (Riversleigh)	Central Sector (Boodjamullah)	Western Sector (Musselbrook)	Total
Elliott traps	18	27	18	63
Pit-fall Traps	14	24	18	56
Plastic Slip Traps	8	-	-	8
Harp Trap Sites	4	7	-	11
Anabat Sites	17	30	-	47
Spotlighting Sites	18	31	-	49

Table 2. Mammal Survey Dates in Each Sector of Riversleigh WHA and Boodjamullah National Park.

Year	Southern Sector (Riversleigh)	Central Sector (Boodjamulla)	Western Sector (Musselbrook)
1998	12 June-17 July	12 June-17 July	
1999	28 May-10 June	28 May-10 June	
2000	14-29 June	14-29 June	
2001	14-30 June	14-30 June	
2002	18-28 June	18-28 June	
2003	7-12 April 20 June- 3 July	20-24 April 20 June-3 July	13-18 April
2004	26 June-5 July	26 June –5 July	3-8 May

Pit Traps: 30 m lengths of 40 cm high mesh fence were set out in each trap site and four 20 l pit buckets were dug in along the fence line (Figure 6). The buckets were uncovered and rocks were placed in the bottom of the bucket to provide some shelter for animals that had fallen in. Pit buckets were left in place for five days and checked every morning and evening.

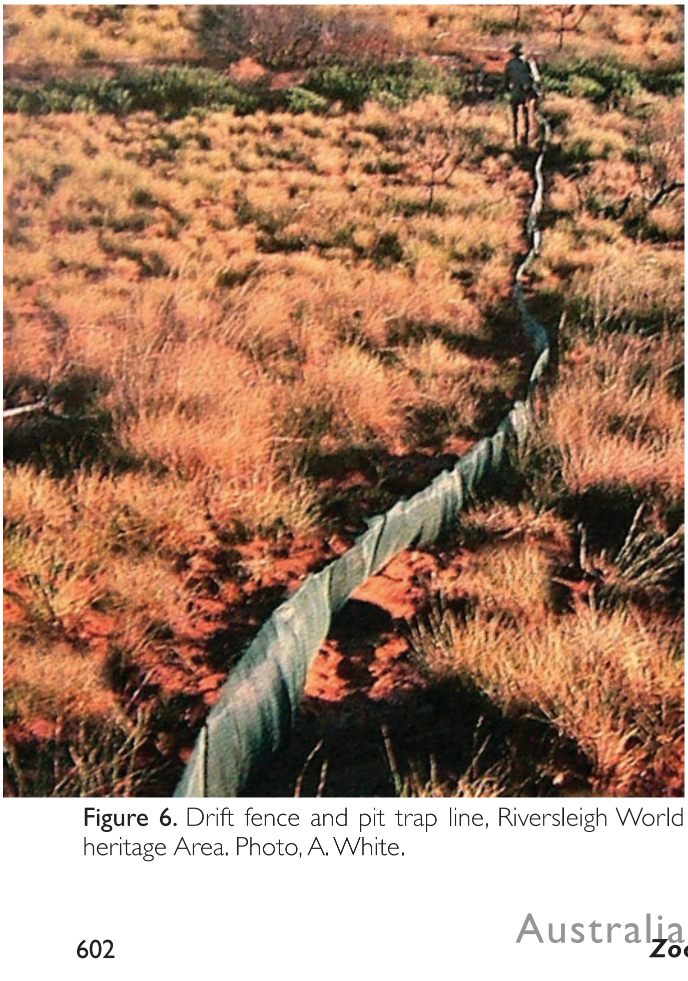

Figure 6. Drift fence and pit trap line, Riversleigh World heritage Area. Photo, A. White.

Cage Traps: 50 cm x 30 cm steel cage traps were only used by the EPA in the 2003 and 2004 surveys. Each Elliott trap line had two cage traps set along it. The cage traps were also checked each morning and evening and left in place for 5 days.

Harp Traps: Harp traps were used in selected locations where bats had been observed flying. As much of the country is open savanna, the locations available for placing the harp traps were quite limited and bat trapping sites tended to be along wooded watercourses or around the edge of limestone or sandstone escarpments. Harp traps were erected and left in place for two consecutive nights only. The traps were checked and emptied late each night and closed during the day.

Anabat: Hand-held Anabat detectors were used to opportunistically survey any areas where bats were seen flying. The recorders were used for the first two hours after dusk each night. In general, the detectors were used along watercourses, around water holes, in caves and deep fissures and in abandoned mines. The recordings were analysed using Anabat 5.0 software.

Plastic slip traps: in the limestone regions of the park, large sheets of plastic (builders membrane) were suspended across fissures or erosion wells to form a slippery sided pit (Figure 7). The ends of the membrane were held down by placing rocks on the membrane and some small pebbles were dropped into the centre of the sheet to create a conical slope and to hold the membrane in place during windy days. These traps were quite effective in catching reptiles (White 2003) but also collected some small mammals. The traps were checked and emptied every morning and evening. As these traps were used primarily for the herpetological surveys, they were left in place for 10 days at a time.

Spotlighting: Spotlighting was used extensively throughout the survey. In open country, 50 watt hand held spotlights were used, either from slowly moving vehicles or while walking cross-country. In closed country or in caves, 20 watt miner's headlamps were used to search low trees or rocky shelves or fissures. Spotlighting took place during the first four hours following dusk. Most spotlighting surveys were site-based but some surveys were undertaken as tracks or droppings of mammals had been found in the area during the day. Some sites were also investigated on the basis of information provided by members of the local Waanyi Aboriginal group. If spotlighting did not take place for 30 minutes or more at a location, it was not recorded in this survey as a spotlighting site.

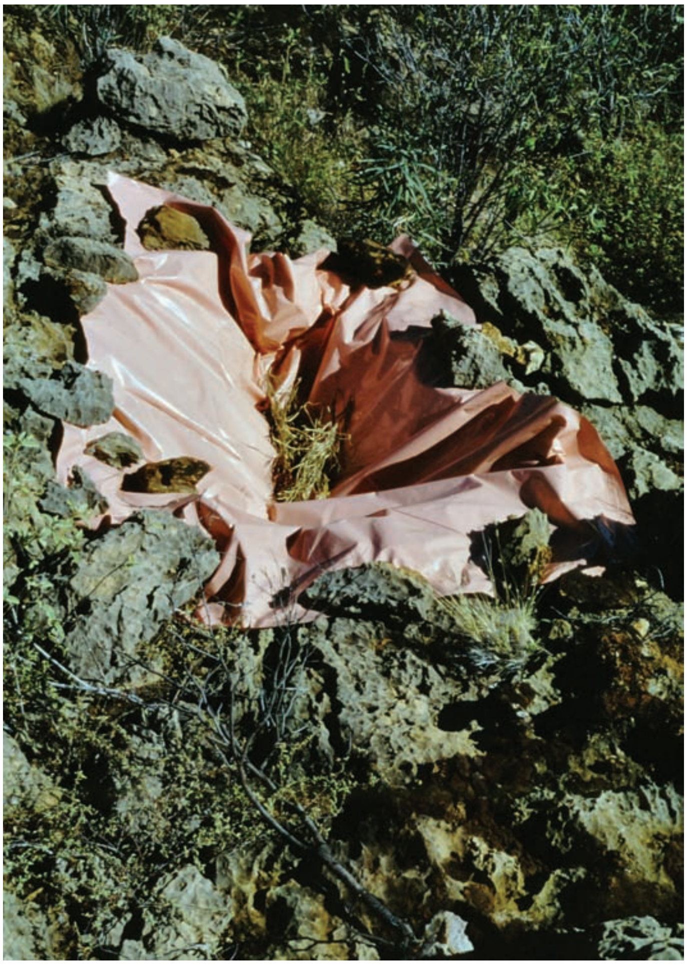

Figure 7. Plastic slip tarps set in limestone fissures, Riversleigh World heritage Area. Photo, A. White.

Opportunistic Sightings: Sightings of mammals were made when moving between survey areas and these were also recorded. The location of each observation was determined using a hand-held GPS unit. Scats, bones and fur were collected and tracks, burrows and other indications of the presence of mammals were recorded.

The identity of small mammals was confirmed on site by either Professor Mike Archer or Mr Henk Godthelp.

Owl Pellet and Cave Deposits

Riversleigh and Boodjamullah contain a number of caves and overhangs where owl pellets and bones have recently accumulated. Many of these sites have only had a cursory collection of material and the results are unpublished. These sites provide the only comparative mammal remains that allow for some interpretation of possible recent changes in the mammal fauna in this region of the Gulf of Carpentaria. Bones and scats were collected from these sites between 1986 and 1996; the ages of the pellets or deposits are unknown.

Results

Mammal Biodiversity

Trapping and spotlighting techniques detected 34 native mammals and 5 introduced mammal species. Table 3 lists the species detected and the method of detection.

Some owl pellets and cave deposits from Riversleigh and Boodjamullah have been examined by Henk Godthelp from the University of New South Wales. The results below represent the early but incomplete analysis of this material.

Mammal Abundance

The abundance of terrestrial mammals can be assessed from the combined trapping results from the pit traps and Elliott Traps. Pit traps caught on average twice the number of animals (0.034 animals/pit/per night; Table 6) than Elliott traps (0.021; Table 5) the overall capture rates for the two techniques combined was 0.023 animals/trap/per night : this equates to one animal being captured every 40 trap nights.

Comparative Detection Success

Each detection method was more successful in certain land units; for example Elliott traps had relatively low capture rates in the Open Plains Savanna whereas pit traps had their highest capture rates there (Table 5 and 6). Pit traps, on the other hand, were completely unsuccessful at catching mammals in gallery rainforest sites where Elliott traps had some captures. Spotlighting (Table 7) was most successful in Limestone Woodland because of the large number of bats sighted flying from caves and fissures. Spotlighting was least successful in gallery rainforest.

Anabat surveys were most successful in gallery rainforest areas with species richness being three times greater than that for all other vegetation assemblages (Table 8).

Mammal Diversity

Nine species of macropods were detected during this study, including the first detection of Spectacled Hare-wallabies in this part of north-western Queensland for 90 years. These secretive macropods were detected in only three locations at Riversleigh and Boodjamullah. Three species of rock wallaby *Petrogale* were recorded with the Purple-faced Rock Wallaby *P. purpuricollis* (Figure 8) being the most abundant and widespread of the three species. The Black-footed Rock Wallaby was only sighted in the Musselbrook sector of the Boodjamullah National Park, close to the Northern Territory border. Another rock wallaby, believed by us to be undescribed, was found mainly in the limestone areas of Riversleigh and Boodjamullah; no complete specimens of this animal have been obtained for taxonomic study, and its taxonomic status is yet to be determined. Antelopine wallaroos were the least common kangaroo species with only two sightings being made in the area since 1986 (A. White unpubl. data).

Dasyurids were represented by three species, *Sminthopsis macroura* (Figure 9), *S. crassicaudata* and *Planigale ingrami*. *S. crassicaudata* was the least common of the three species while *S. macroura* was the most commonly caught terrestrial mammals in Plains Open Woodland.

Possums were not abundant or diverse; only two species were found. The Northern Brushtail Possum *Trichosurus vulpecula arnhemensis* was only sighted on two occasions, both times

Table 3. Summary of Mammal Species Detected and Method of Detection

Mammal Group	Species	Common Name	Park Sections	Land Unit	Method of Detection
Monotremes	*Tachyglossus aculeatus*	Short-beaked Echidna	R,B	POW, LW SSW	Spotlight, observation
Marsupials	*Planigale ingrami*	Long-tailed Planigale	R,B	POW, SSW	Elliot Trap, Pit Trap
	Sminthopsis crassicaudata	Fat-tailed Dunnart	B	SSW	Elliot Trap
	Sminthopsis macroura	Striped-faced Dunnart	R,B.M	POW, LW, SSW	Elliot Trap, Pit Trap
	Trichosurus vulpecula arnemhensis	Northern Brushtail Possum	B	GR	Spotlight
	Petropseudes dahli	Rock-ringtail Possum	B	SSW	Spotlight
	Macropus rufus	Red Kangaroo	R,B.M	OPS	Spotlight
	Macropus antilopinus	Antilopine Wallaroo	R	OPS	Spotlight,observation
	Macropus agilis	Agile Wallaby	R.B.M	POW, LW.	Spotlight,
	Macropus robustus erubescens	Euro	R,B,M	SSW	Observation
	Petrogale purpuricollis	Purple-faced Rock Wallaby	R,B		Spotlight, observation
	Petrogale lateralis	Black-footed Rock Wallaby	M	LW, SSW	Spotlight, observation
	Petrogale sp #	Undescribed Rock Wallaby	R,B	LW, SSW	Observation
	Onychogalea unguifera	Northern Nailtail Wallaby	R,B	POW, LW	Spotlight, observation
	Lagorchestes conspicillatus	Spectacled hare-wallaby	R,B	POW, LW	Spotlight, observation
Rodents	*Hydromys chrysogaster*	Eastern Water Rat	B	GR	Spotlight
	Pseudomys nanus	Western Chestnut Mouse	R	LW	Elliot Trap
	Pseudomys desertor	Desert Mouse	M	SSW	Pit Trap
	Pseudomys delicatulus	Delicate Mouse	R,M	LW, SSW	Elliot Trap, Pit Trap
	Leggadina lakesdownensis	Northern Short-tailed Mouse	R.B	LW, SSW	Elliot Trap, Pit Trap
	Zyzomys argurus	Common Rock Rat	R,B,M	LW, SSW	Elliot Trap, Pit Trap
Bats	*Pteropus scapulatus*	Little Red Flying Fox	R,B	GR	Spotlight
	Hipposideros ater	Dusky Horseshoe Bat	R,B	LW	Harp Trap, Anabat
	Hipposideros stenotis	Lesser Wart-nosed Horseshoe Bat	R	LW	Harp Trap
	Rhinonicteris aurantius	Orange Horseshoe Bat	B	LW	Spotlight
	Taphozous georgianus	Common Sheathtail Bat	R,B	LW	Spotlight, Harp Trap, Anabat
	Taphozous flaviventris	Yellow-bellied Sheath-tail Bat	R	LW	Anabat
	Chaerephon jobensis	Northern Mastiff Bat	B	LW	Spotlight, Harp Trap
	Nycophilus geoffroyi	Lesser Long-eared Bat	R,B	LW	Harp Trap
	Nyctophilus bifax	North Queensland Long-eared Bat	R,B	LW	Anabat, Harp Trap
	Nyctophilus walker	Pygmy Long-eared Bat	R,B	GR, LW	Anabat, Harp Trap
	Chalinolobus gouldii	Gould's Wattled Bat	R.B	GR, LW	Anabat, Harp Trap
	Myotis macropus	Mouse-eared Fishing Bat	R,B	GR, LW	Anabat, Harp Trap
	Scotorepens greyii	Little Broad-nosed Bat	R,B	LW, SSW	Anabat, Harp Trap
	Vespadelus findlaysoni	Inland Cave Bat	B	LW, SSW	Anabat, Harp Trap
Canids	*Canis lupus dingo*	Dingo	R,B	POW, LW, SSW	Spotlight
Feral Mammals	*Sus scrofa*	Pig	R,B	POW, GR, SSW	Spotlight
	Felis catus	Cat	R	GR	Spotlight
	Mus musculus	House Mouse	R,B	POW, SSW	Elliot Trap, Pit Trap
	Bos indicus	Wild Cattle	R,B	SSW	Spotlight
	Bubalis bubalis	Water Buffalo	B		Observation, tracks

Park Sections: R= Riversleigh; B = Boodjamullah; M = Musselbrook.

Vegetation Assemblage: GR = Gallery Rainforest; LW = Limestone Woodland; SSW = Sandstone Woodland; POW= Plains Open Woodland.

#Partial skeletal material from this rock wallaby has been examined by Assoc. Prof. Robert Close of the University of Western Sydney. Initial analysis indicates that this animal is either an undescribed species within the *Petrogale brachyotis* species assemblage, or is a regional variant of the Short-eared Reck-wallaby *Petrogale brachyotis.*

Table 4. Owl Pellet Results

Site	Sector	Nature of Material	Mammals identified to Date
Message Stick Cave	Riversleigh	Owl Pellets and cave floor deposits	*Dasyuroides* sp. *Mesembriomys* sp. *Sminthopsis* sp. Rodents various
Louie Creek Cave	Boodjamullah	Owl Pellets and cave floor deposits	*Sminthopsis* sp. Rodents various
Letterbox Cave	Boodjamullah	Owl Pellets	*Macroderma* sp. *Taphozous* sp. *Petrogale* sp. *Dasyurus* sp. *Sminthopsis* sp. *Rattus* sp. cf *villosisimus* Rodents various
Tunnel Cave	Boodjamullah	Owl Pellets	Rodents various
Carrington Cave	Riversleigh	Owl pellets and Ghost Bat pellets	*Sminthopsis* sp. *Planigale* sp. Rodents various *Macroderma* sp.
Boundary Deposit	Riversleigh/Boodjamullah	Owl Pellets and cave floor deposits	*Rattus* sp cf *villosisimus* *Sminthopsis* sp. *Planigale* sp.

Table 5. Summary data for Elliott Traps

Vegetation Assemblage	No. Sites Trapped	Total No of Trap Nights	Total No of Animals Caught	Total No of Species Caught	% Trap Success (animals/trap/night)
Plains Open Woodland	6	600	6	3	1.0
Limestone Woodland	15	1500	49	6	3.2
Sandstone Woodland	38	3800	73	5	1.9
Gallery Rainforest	4	400	3	2	0.75
Totals	63	6100	131	16	2.14

Table 6. Summary Data for Pit Traps

Vegetation Assemblage	No. Sites Trapped	Total No of Trap Nights	Total No of Animals Caught	Total No of Species Caught	Relative Catch Rate (animals/trap/night)
Plains Open Woodland	7	112	12	4	8.1
Limestone Woodland	12	192	13	4	5.4
Sandstone Woodland	30	248	11	3	1.8
Gallery Rainforest	4	32	0	0	0.0
Totals	53	584	36	11	3.37

Table 7. Summary Results for Spotlighting

Vegetation Assemblage	Total No of Spotlighting Nights	Total No of Animals Seen	Total No of Species Seen	Relative Observation Rate (animals/night)
Plains Open Woodland	7	69	7	9.8
Limestone *Woodland	19	301	13	15.8
Sandstone Woodland	16	8	10	6.6
Gallery Rainforest	8	29	6	3.6

* includes cave sites

Table 8. Summary Data for Anabat Results

Vegetation Assemblage	Total No of Recording Nights	Total No of Species Detected	Relative Observation Rate (animals/night)
Plains Open Woodland	5	5	1.00
Limestone Woodland	6	7	1.17
Sandstone Woodland	3	3	1.00
Gallery Rainforest	13	14	3.23

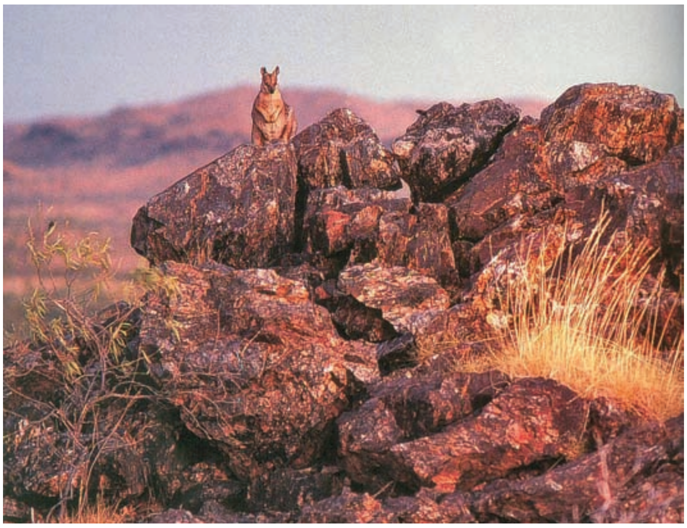

Figure 8. Purple-faced Rock-wallaby *Petrogale purpuricollis* on sandstone outcrop, Boodjamullah National Park. Photo, A. White.

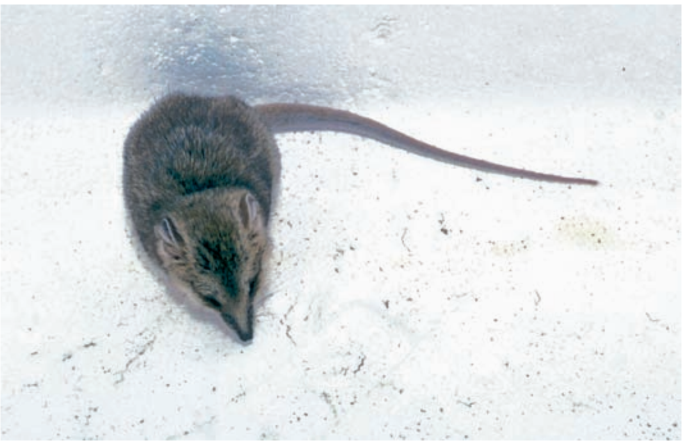

Figure 9. Striped-faced Dunnart *Sminthopsis macroura* in pit bucket. Photo, A. White.

near Adels Grove in Boodjamullah. In contrast, Rock-haunting Ringtail Possums *Petropseudes dahli* (Figure 10) was found to be widespread in the sandstone escarpments along the Constance Ranges in the Boodjamullah National Park. No gliders were detected despite Sugar Gliders *Petaurus brevipes* being present in the lower floodplain of the Gregory River (Winter *et al.* 2004)

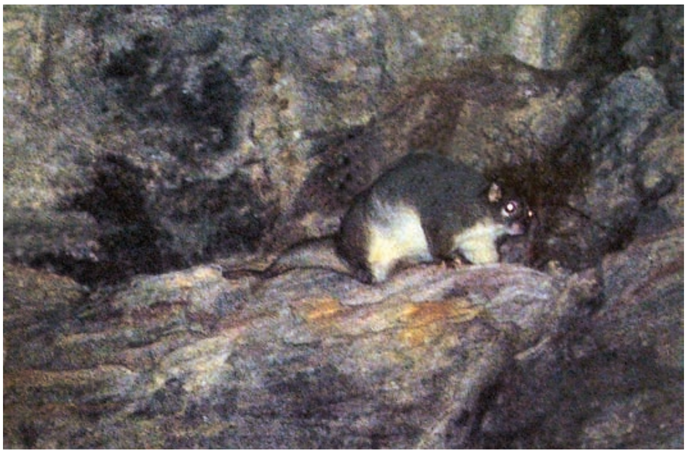

Figure 10. Rock Ringtail Possums *Petropseudes dahli*, Island Stack, Boodjamullah National Park. Photo, A. White.

Six species of rodents were recorded during the survey species, the only relatively abundant rodent caught was the Common Rock Rat *Zyzomys argurus* (Figure 11). These rodents were found in most sandstone and limestone outcrops. *Leggadina* and *Pseudomys* were found mainly in open woodland or on the open plains. They were particularly uncommon. *Hydromys* was found along Lawn Hill Creek in the Boodjamullah National Park and the Gregory River at Riversleigh. No *Rattus* species were found.

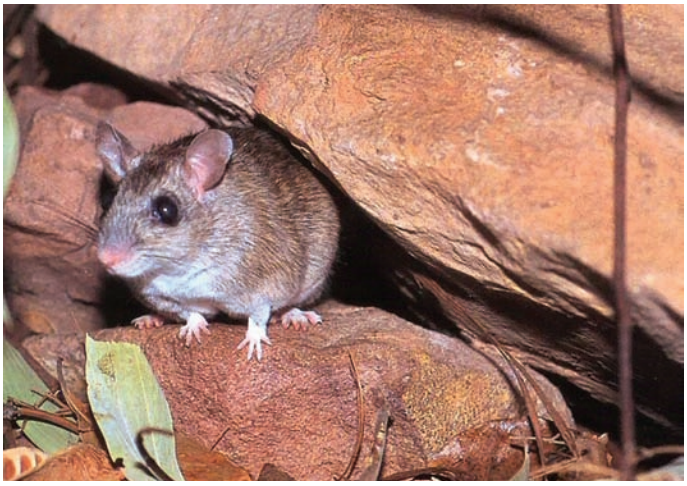

Figure 11. Common Rock Rat *Zyzomys argurus*, Riversleigh World Heritage Area. Photo, A. White.

Fourteen species of bats were detected; only one species of flying-fox, the Little Red Flying Fox *Pteropus scapulatus* was detected. In 2001 and 2002, these flying-foxes established a camp of between 14,000 and 20,000 individuals (A. White pers. data) on Louie Creek. The camp was then abandoned and since then only low numbers of flying-foxes have been sighted in the area. Little Red Flying-foxes are known to be highly nomadic and to range across large areas (Nelson 1965). Many of the microbats that were detected were cave-dwellers (Figure 12) or resided in the dense foliage of trees bordering the larger rivers and creeks. Most microbats were detected multiple times with the exception of the Lesser Wart-nosed Horseshoe Bat *Hipposideros stenotis* and the Yellow-bellied Sheath-tail Bat *Taphozous flaviventris*, these two species were only detected once during the surveys.

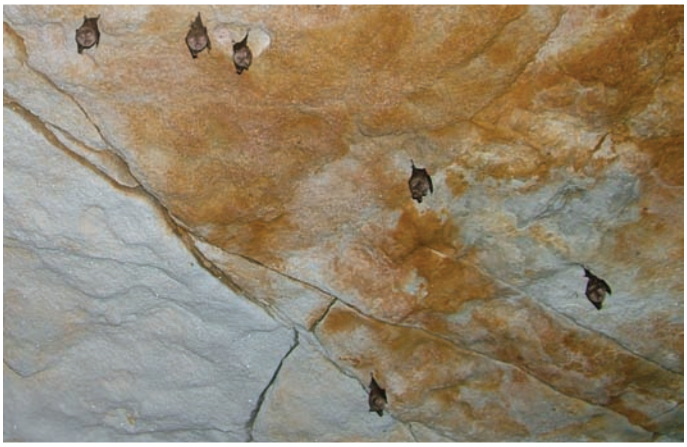

Figure 12. Dusky Horseshoe Bats *Hipposideros ater* on roof of Letterbox Cave, Boodjamullah National Park. Photo, A. White.

Discussion

Mammal Biodiversity

The diversity of mammals was less than might have been expected based solely on the geographic range of mammals species in Australia (Van Dyck and Strahan 2008). Forty native mammal species have ranges that include the Riversleigh–Boodjamullah area; the present study detected 34 of these. The most diverse mammal groups that were detected were macropodid marsupials and vepertilionid bats.

Mammal Abundance

While it is difficult to compare the results of surveys from different regions and habitats of northern Australia, the overall mammal catch rates (2% in Elliott traps) in these surveys appears to be low. Extensive surveys carried out in a range of habitats in the Northern Territory (Woinarski *et al* (2001) had capture rates for all small mammals of 3.3% in their large grids, higher than for the present study. The Northern Territory study was designed to test an earlier hypothesis by Braithwaite and Muller (1997) that declining mammal numbers from the 1980s to the early 1990s were due to a series of dry years and falling water tables. By resampling following a series of good years, Woinarski *et al.* (2001) showed that this hypothesis did not hold and that the decline was probably due to other unspecified factors.

One of the main aspects of the low overall abundance of mammals at Riversleigh and Boodjamullah was the relative scarcity of rodents. Only one species was abundant, the Common Rock Rat *Zyzomys argurus,* but this species was confined to rocky ridges and escarpments. The more open habitats often yielded no rodents or only one or two animals. Other rodent species were expected such as *Rattus* species (Covacevich and Easton 1974). Dasyurids were 10 times more abundant in Plains Open Woodland and Limestone Woodland areas with the Striped-faced Dunnart *Sminthopsis macroura* being the most abundant dasyure in the study area.

The cause and persistence of the low abundance of mammals cannot be confirmed by the present study; follow up trapping programs are required to determine whether these capture rates are typical or reflect some temporary or seasonal impact. As most of the trapping work in the present study was carried out during the winter months, it was possible that there was a seasonal bias in the results. However, Woinarski *et al.* (2001) analysed their own trapping data and found that, in general, trapping results within any month gives a good indication of the fluctuations in mammal abundance. This means that if there were seasonal outbreaks in the populations of rodents in response to wet season growth, winter trapping studies should still detect these changes in animal numbers.

If we accept that the terrestrial mammal abundances are low at Riversleigh and Boodjamullah, it remains to be demonstrated if this is a cyclic response to broad-term weather and climate changes or is in response to more immediate impacts. In 1986 and 1987 respectively, Cane Toads *Bufo marinus* reached Boodjamullah and Riversleigh; these exotic amphibians had an immediate impact on the local herpetofauna (White 2003) but their effect on the mammal fauna, other than *Dasyurus* (Oakwood 2004), is unknown.

Mammal Utilisation of Vegetation Associations

Native terrestrial mammals were most diverse in area of Limestone or Sandstone Woodland (13 of 22 species); 9 species inhabited the Plains Open Woodland while only two were detected in gallery rainforest areas (Table 3). Limestone and Sandstone Woodlands were also found to contain the greatest variety of terrestrial reptiles (White 2003) and this was attributed to the greater amount of shelter habitat available in these land units. Limestone areas in particular are replete with fissures, clefts, potholes, caves and tunnels, as well as loose boulders and talus. Sandstone areas contain deep gorges and layered escarpments with some talus areas. The Plains Open Woodland, by comparison is devoid of solid ground cover materials but does contain deep cracks and gilgais where smaller terrestrial animals can refuge. Dense ground cover is provided by spinifex and other tussock plants. Open Plains Savanna is heavily exploited by free-ranging herbivores, notably macropods.

Gallery Rainforest had the highest diversity of bats (Table 7) but was otherwise quite poor for other mammal species. Bats were often detected flying over water, drinking or foraging for insects above the water bodies.

Comparison with Owl Pellets and Cave Deposits

Owl pellet data and bones found in recent cave deposits attests to the past presence of different mammals in the area. Animals, such as *Dasyuroides*, *Antechinomys* and *Rattus*, were not found in the present survey but were present in several owl pellet deposits in the survey area (Table 4) and in the nearby Camooweal Nation Park (Cox 2004). Furthermore, larger species such as bandicoots and quolls, were also present, species that would normally be detected during surveys if present because of their active foraging habits. Unfortunately, as these deposits are undated, it is not possible to know how long ago mammals such as *Dasyurus* and *Rattus* were still present in the survey area.

Perhaps the most distinctive difference between the species found in this survey and those present in owl pellets is the great diversity of rodents in the owl pellets. Even allowing for prey selectivity by owls, the large diversity of rodents compared to other species suggests that many more species of rodents were present in this area in the recent past.

Mammal Declines

The low trap numbers of mammals found during this study suggest a relative scarcity of small terrestrial mammals in the Riversleigh-Boodjamullah area. With the available information, it is not possible to know if this situation is typical for the area or has resulted from some recent external impact. If the owl pellet and cave deposit data are of recent origin, this suggests that a more diverse mammal fauna existed in this area until quite recently and that there has been a significant change in small mammal diversity.

Declines in the small, non-macropodid terrestrial mammals have been reported elsewhere in northern Australia (e.g. Woinarski *et al.* 2001, Kutt *et al.* 2005). Various agents have been proposed to account for the decline in the small mammals, such as altered fire regimes, impact of grazing, disease and exotic predators (Woinarski *et al.* 2007). Of these, only the impact of fire has been well assessed; in the Northern Territory and Western Australia significant changes in the ground cover vegetation has resulted from increased burning (Woinarski *et al.* 2004 a,b; Anderson *et al.* 2005). Woinarski *et al.* (2004b) compared the faunas of burnt and unburnt areas in tropical woodland and found that burning caused a major change in species composition, with a range of mammals being adversely impacted by fire. On the other hand, the species richness did not change as other mammal species are able to inhabit and exploit burnt areas.

The impact and incidence of fire at Riversleigh and Boodjamullah is not well documented but it has been suggested that fires have become less frequent in the area as a result of increased grazing in the flat country (Mason 2002). In the last 10 years there have been two significant fire events, in 1997 when a relatively small fire affected the southern parts of Boodjamullah and Riversleigh, and in October 2001 when an extensive fire burned three-quarters of the land area of the Boodjamullah National Park. Previous fires at Boodjamullah have left tell tale changes in the vegetation with the loss of fire-sensitive trees and shrubs and an increase in exotic weeds such as Buffel Grass *Cenchrus ciliaris*, Giant Mimosa *Mimosa pigra* and assorted acacia (e.g. *A. niloticus, A. farnesiana*). Buffel Grass has already been noted as invading areas previously dominated by Spinifex *Triodia spp* (Mason 2002). Aboriginal burning of the limestone and sandstone areas occurred less frequently that in the flat country.

The impact of grazing in tropical savanna has been recently assessed. Woinarski and Ash (2008) found that, like fire, pastoralism leads to a marked change in the species composition of an area. Ground mammals that inhabit tussock areas were adversely affected with some species no longer being detected. Other mammal species, including exotic rodents and predators, are advantaged by pastoralism, so species diversity may not change.

The present study does not shed any light as to the possible reasons for decline or change in diversity of small mammals at Riversleigh and Boodjamullah, but it is evident that systematic and repeated surveys of the terrestrial mammals should occur to determine whether low mammal numbers perish over time.

Acknowledgements

This survey would not have been possible if not for the considerable assistance given by many people. The Waanyi people who are the custodians of this land were very kind in allowing me access to special areas within the Riversleigh WHA and the Boodjamullah National Park. They also provided useful insights and discussion into potential habitat areas for certain species. Their interest in the project was greatly appreciated. Many people offered to assist with setting and checking traps, exploring new terrains, carrying gear or helping with vehicle maintenance. In particular, I would like to thank Harry Burgen, Rod Low Mow, John Prince, Gaffer Florence, Frank Nissan, Henry Doomadgee, Des Peters, Mark Breen, Maria Kohl, David Robertson and the many Earthwatch and other volunteers who assisted with the project. Thanks are also due to the National Parks staff based at Lawn Hill and Mt Isa for their assistance, particularly David Williams and Eleanor Collins. Many thanks are due to Michelle Nissan. The survey was carried out under licence no. 00261/00/SAA.

References

Andersen, A.N., Cook, G.D., Corbett, L.K., Douglas, M.M., Eager, R.W., Russell-Smith, J., Setterfield, S.A., Williams, R.J., and J.C.Z. Woinarski. 2005. Fire frequency and biodiversity conservation in Australian tropical savannas: implications for the Kapalga fire experiment. *Austral Ecology* 30: 155-167.

Archer, M., Hand, S. & Godthelp, H. 1991. *Riversleigh. The Story of Animals on Ancient Rainforests of Inland Australia*. Reed Books, Balgowlah.

Bean, T. 1991. Report on the vegetation of Riversleigh. Queensland National Parks and Wildlife Service.

Braithwaite, R.W., and Muller, W.J. 1997. Rainfall, groundwater and refuges: Predicting extinctions of Australian tropical mammal species. *Australian Journal of Ecology* 22; 57-67.

Burbidge, A.A., and McKenzie, N. L. 1989. Patterns in the modern decline of Western Australia's vertebrate fauna: causes and conservation implications. *Biological Conservation* 50:143-198.

Collett, R. 1885. On a collection of mammals from central and northern Queensland. *Proceedings of the Zoological Society of London* 2:829-940.

Covacevich, J., and A. Easton. 1974. *Rats and Mice in Queensland*. Queensland Museum Booklet No. 9. Fortitude Valley, Queensland.

Cox, T. 2004. The use of barn owl (*Tyto alba*) pellets to identify prey species, and to determine species presence and abundance in the Camooweal area. Research report ANIM4611. University of Queensland.

Dovers. S.R. 2000. On the contribution of environmental history to current debate and policy. *Environment and History* 6:131-150.

Kirkpatrick, T.H., and H.J. Lavery. 1979. Fauna surveys in Queensland. *Queensland Journal of Agriculture and Animal Science* 36:181-188.

Kutt, A.S., Bolitho, E.E., Retallick, R.W.R., and Kemp, J.B. 2005. Pattern and Change in the Terrestrial Vertebrate Fauna of the Pennefather River, Gulf of Carpentaria, Cape York peninsula", in *Gulf of Carpentaria Scientific Study Report*, Geography Monograph Series No. 10. Royal geographical Society of Queensland Inc, Brisbane. Pp 261-300.

Mason, D.R. 2002. Fire management and research in Northwestern Queensland National Parks. Southern Gulf Links September 2002.

Oakwood, M. 2004. Reproduction and demography of the northern quoll, *Dayurus hallucatus*, in the lowland savanna of northern Australia. *Australian Journal of Zoology* 48:519-539.

Queensland Department of Primary Industries. 1974. Western arid region land use study, Part 1. Division of land utilization technical Bulletin 12.

Nelson, J.E. 1965. Movements of Australian flying foxes (Pteropidae: Megachiroptera). *Australian Journal of Zoology* 13:53-73.

Trainor, C., Fisher, A., and Churchill, S. 1998. Comparison of frequency of occurrence of the Carpentarian Rock Rock *Zyzomys palatalis* across like environmental units in the Northern Territory and Queensland. Musselbrook Reserve Scientific Study report. Royal Geographic Society of Queensland. Pp 303-311.

Van Dyck, S., and Strahan, R. (eds). 2008. *The Mammals of Australia*, 3rd ed. Reed New Holland, Sydney.

White, A.W. 2003. Herpetofauna of Boodjamulla National Park and the Riversleigh World Heritage Area, north-western Queensland. *Herpetofauna* 33(2): 65-77.

Winter, J.W., Dillewaard, H.A., Williams, S.E. and Bolitho, E.E. 2004. Possums and gliders of north Queensland: distribution and conservation status. Pp27-50 in *The Biology of Australian Possums and Gliders, edited by* R. Goldingay and S.M. Jackson. Surrey Beatty and Sons P.L., Chipping Norton.

Woinarski, J.C.Z. 2007. Mammal status in northern Australia. Project 1.2.2. Tropical Savanna CRC www.savanna.org.au/savanna_web/research/projects/mammal_decline

Woinarski, J.C.Z., and Ash, A.J. 2008. Responses of vertebrates to pastoralism, military land use and landscape position in an Australian tropical savanna. *Austral Ecology* 27: 311-323.

Woinarski, J.C.Z., and R.W. Braithwaite. 1990. Conservation foci for Australian birds and mammals. *Search* 21: 65-69.

Woinarski, J.C.Z., Milne, D.J., and Wanganeen, G. 2001. Changes in the mammal populations in relatively intact landscapes of Kakadu National Park, Northern Territory, Australia. *Austral Ecology* 26: 360-370.

Woinarski, J.C.Z., Armstrong, M., Price, O., McCartney, J., Griffiths, T., and Fisher, A. 2004a. The terrestrial vertebrate fauna of Litchfield National Park, Northern Territory: monitoring over a six year period and response to fire history. *Wildlife Research* 31: 1-10.

Woinarski, J.C.Z., Risler, J., and Kean, L. 2004b. The response of vegetation and vertebrate fauna to 23 years of fire exclusion in a tropical *Eucalyptus* open forest, Northern Territory, Australia. *Austral Ecology* 29: 156-176.

Woinarski, J.C.Z., Mackey,B., and Traill, B. 2007. *The nature of northern Australia: its natural values, ecological processes and future prospects.* ANU E Press, Canberra.

APPENDIX I

Capture and Detection Data for Elliott, Pit Fall Trap, Harp Trap, Anabat, Slip Trap and Spotlighting Sites

Site No	Location	Survey Type	Number and Species Found
ET1	Valley below Godthelps Hill	Elliott Traps	*1 Sminthopsis macroura*
ET2	S side of Godthelps Hill	Elliott Traps	*2 Sminthopsis macroura* *8 Zyzomys argurus*
ET3	Cleft of Ages Valley	Elliott Traps	*1 Leggadina lakesdownensis* *1 Sminthopsis macroura*
ET4	Gregory Floodplain near Lloyds Camp	Elliott Traps	*2 Planigale ingrami* *1 Pseudomys delicatulus*
ET5	Mesa to west of Lloyds Camp	Elliott Traps	*14 Zyzomys argurus*
ET6	Mesa near Verdon Creek	Elliott Traps	*11 Zyzomys argurus* *1 Mus musculus*
ET7	Between E site and D site	Elliott Traps	*1 Planigale ingrami* *4 Zyzomys argurus*
ET8	Near Judiths Horizontalis	Elliott Traps	*1 Pseudomys nanus* *2 Zyzomys argurus* *1 Leggadina lakesdownensis*
ET9	Microsite Valley	Elliott Traps	*2 Sminthopsis macroura*
ET10	Louie Creek (Adels Grove)	Elliott Traps	*4 Mus musculus* *4 Zyzomys argurus*
ET11	Boodjamulla Park entrance	Elliott Traps	*2 Sminthopsis macroura* *8 Zyzomys argurus*
ET12	Boodjamulla First Valley	Elliott Traps	*3 Mus musculus* *1 Sminthopsis macroura*
ET13	Observation Hill (Adels Grove)	Elliott Traps	*Nil*
ET14	Island Stack	Elliott Traps	*9 Zyzomys argurus*
ET15	Indarri Falls Lookout	Elliott Traps	*8 Zyzomys argurus*
ET16	Start Constance Range Walking Track	Elliott Traps	*3 Zyzomys argurus*
ET17	Constance Range Track 2 km from start (Edith Range)	Elliott Traps	*2 Planigale ingrami* *1 Sminthopsis crassicaudata*

ET18	Widdalion Creek Floodplain	Elliott Traps	*Nil*
ET19	Widdalion Waterhole	Elliott Traps	*6 Zyzomys argurus*
ET20	Dry Gap	Elliott Traps	*3 Zyzomys argurus*
ET21	Hiatus T1*	Elliott Traps	*Nil*
ET22	Price is Right T2*	Elliott Traps	*Nil*
ET23	Price is Right T3*	Elliott Traps	*Nil*
ET24	Hill next to Price is Right T4*	Elliott Traps	*Nil*
ET25	West of Hiatus T5*	Elliott Traps	*Nil*
ET26	Near Park Boundary T6*	Elliott Traps	*Nil*
ET27	Chapman 1 T7*	Elliott Traps	*Nil*
ET28	Chapman 2 T8*	Elliott Traps	*Nil*
ET29	Chapman 3 T9*	Elliott Traps	*4 Zyzomys argurus*
ET30	Gregory River 1 T10*	Elliott Traps	*Nil*
ET31	Gregory River 2 T11*	Elliott Traps	*Nil*
ET32	Gregory River 3 T12*	Elliott Traps	*Nil*
ET33	Musselbrook 1 3.6 km on hill	Elliott Traps	*Nil*
ET34	Musselbrook 2 3.6 km along creek flat	Elliott Traps	*Nil*
ET35	Musselbrook 3 3.1 km from camp	Elliott Traps	*Nil*
ET36	Musselbrook 4 2.65 km from camp	Elliott Traps	*Nil*
ET37	Musselbrook 5 2.15 km from camp	Elliott Traps	*2 Pseudomys delicatulus*
ET38	Musselbrook 6 1.85 km from camp	Elliott Traps	*Nil*
ET39	Musselbrook 7 near windsock	Elliott Traps	*Nil*
ET40	Musselbrook 8 0.85 km from camp	Elliott Traps	*Nil*
ET41	Musselbrook 9 0.3 km from camp	Elliott Traps	*Nil*
ET42	Musselbrook 10* 0.1 km from camp	Elliott Traps	*Nil*
ET43	Musselbrook 11* 4.25 fr track junction	Elliott Traps	*Nil*
ET44	Musselbrook 12* 4.38 km north of junction	Elliott Traps	*Nil*
ET45	Musslebrook 13	Elliott Traps	*Nil*
ET46	Musselbrook 14	Elliott Traps	*Nil*
ET47	Musslebrook 15	Elliott Traps	*2 Zyzomys argurus*
ET48	Louie Creek Valley Site 1*	Elliott Traps	*Nil*
ET49	Louie Creek Valley Site 2*	Elliott Traps	*Nil*
ET50	Hill above Louie Creek Site 3*	Elliott Traps	*Nil*
ET51	Boodjamulla Resource Reserve Site 4*	Elliott Traps	*1 Zyzomys argurus*
ET52	Boodjamulla Resource Reserve Site 5*	Elliott Traps	*1 Zyzomys argurus*
ET53	Boodjamulla Inside gates Site 6*	Elliott Traps	*1 Zyzomys argurus*
ET54	Boodjamulla north gates Sites 7*	Elliott Traps	*2 Zyzomys argurus*
ET55	Boodjamulla Hill above staff area Site 8*	Elliott Traps	*2 Zyzomys argurus*
ET56	Boodjamulla Hill above Staff Area Site 9*	Elliott Traps	*6 Zyzomys argurus*
ET57	Boodjamulla Island Stack Site 10*	Elliott Traps	*Nil*
ET58	Boodjamulla island Stack Site 11*	Elliott Traps	*4 Zyzomys argurus*
ET59	Dry Gap valley entrance	Elliott Traps	*2 Pseudomys delicatulus*
ET60	Louie Creek below Caves 1 & 2	Elliott Traps	*Nil*
ET61	Louie Creek near Cave 3	Elliott Traps	*Nil*
ET62	Louie Creek valley entrance	Elliott Traps	*Nil*
ET63	Louie Creek near road crossing	Elliott Traps	*1 Zyzomys argurus*

APPENDIX I

Site No	Location	Survey Type	Number and Species Found
PT1	Valley below Godthelps Hill	Pit Traps	*5 Sminthopsis macroura*
PT2	Gate, Gag Plateau	Pit Traps	*2 Sminthopsis macroura* *1 Leggadina lakesdownensis*
PT3	Gregory River upstream of crossing	Pit Traps	*Nil*
PT4	Below Judiths Horizontalis	Pit Traps	*2 Planigale ingrami* *2 Sminthopsis macroura*
PT5	Gregory Floodplain west of Lloyds Camp	Pit Traps	*Nil*
PT6	Gregory Floodplain north of Lloyds Camp	Pit Traps	*Nil*
PT7	Verdon Creek near Road Crossing	Pit Traps	*1 Planigale ingrami* *1 Pseudomys nanus*
PT8	Louie Creek Valley east of Cave 1	Pit Traps	*1 Planigale ingrami* *2 Sminthopsis macroura*
PT9	Louie Creek Valley entrance	Pit Traps	*Nil*
PT10	Louie Creek Valley near Cave 3	Pit Traps	*1 Leggadina lakesdownensis*
PT11	Near Lilydale Mine	Pit Traps	*2 Leggadina lakesdownensis*
PT12	Near Riversleigh/Lawn Hill station boundary	Pit Traps	*1 Sminthopsis macroura*
PT13	Verdon Rock	Pit Traps	*Nil*
PT14	Louie Creek Floodplain 1	Pit Traps	*1 Leggadina lakesdownensis*
PT15	Louie Creek Floodplain 2	Pit Traps	*Nil*
PT16	Louie Creek Floodplain 3	Pit Traps	*2 Sminthopsis macroura*
PT17	Hiatus T1*	Pit Traps	*Nil*
PT18	Price is Right T2*	Pit Traps	*Nil*
PT19	Price is Right T3*	Pit Traps	*Nil*
PT20	Hill next to Price is Right T4*	Pit Traps	*1 Sminthopsis macroura*
PT21	West of Hiatus T5*	Pit Traps	*Nil*
PT22	Near Park Boundary T6*	Pit Traps	*Nil*
PT23	Chapman 1 T7*	Pit Traps	*Nil*
PT24	Chapman 2 T8*	Pit Traps	*Nil*
PT25	Chapman 3 T9*	Pit Traps	*Nil*
PT26	Gregory River 1 T10*	Pit Traps	*Nil*
PT27	Gregory River 2 T11*	Pit Traps	*Nil*
PT28	Gregory River 3 T12*	Pit Traps	*Nil*
PT29	Musselbrook 1 3.6 km on hill	Pit Traps	*Nil*
PT30	Musselbrook 2 3.6 km along creek flat	Pit Traps	*1 Planigale ingrami*
PT31	Musselbrook 3 3.1 km from camp	Pit Traps	*Nil*
PT32	Musselbrook 4 2.65 km from camp	Pit Traps	*Nil*
PT33	Musselbrook 5 2.15 km from camp	Pit Traps	*Nil*
ET34	Musselbrook 6 1.85 km from camp	Pit Traps	*Nil*
PT35	Musselbrook 7 near windsock	Pit Traps	*Nil*
PT36	Musselbrook 8 0.85 km from camp	Pit Traps	*Nil*
PT37	Musselbrook 8 0.85 km from camp	Pit Traps	*2 Pseudomys delicatulus*
PT38	Musselbrook 9 0.3 km from camp	Pit Traps	*Nil*
PT39	Musselbrook 10* 0.1 km from camp	Pit Traps	*Nil*
PT40	Musselbrook 11* 4.25 fr track junction	Pit Traps	*Nil*
PT41	Musselbrook 12* 4.38 km north of junction	Pit Traps	*Nil*
PT42	Louie Creek Valley Site 1*	Pit Traps	*Nil*
PT43	Louie Creek Valley Site 2*	Pit Traps	*1 Zyzomys argurus*
PT44	Hill above Louie Creek Site 3*	Pit Traps	*Nil*
PT45	Boodjamulla Resource Reserve Site 4*	Pit Traps	*Nil*

PT46	Boodjamulla Resource Reserve Site 5*	Pit Traps	*2 Zyzomys argurus*
PT47	Boodjamulla Inside gates Site 6*	Pit Traps	*Nil*
PT48	Boodjamulla north gates Sites 7*	Pit Traps	*Nil*
PT49	Boodjamulla Hill above staff area Site 8*	Pit Traps	*Nil*
PT50	Boodjamulla Hill above Staff Area Site 9*	Pit Traps	*1 Zyzomys argurus*
PT51	Boodjamulla Island Stack Site 10*	Pit Traps	*1 Zyzomys argurus*
PT52	Boodjamullah Island Stack Site 11*	Pit Traps	*1 Zyzomys argurus*
PT53	Dry Gap Valley Entrance	Pit Traps	*1 Zyzomys argurus*
PT54	Boodjamulla Park entrance	Pit Traps	*1 Zyzomys argurus*
PT55	Musslebrook 13	Pit Traps	*1 Zyzomys argurus*
PT56	Musselbrook 14	Pit Traps	*2 Zyzomys argurus*
PT 57	Musslebrook 15	Pit Traps	*2 Zyzomys argurus*
Site No	**Location**	**Survey Type**	**Number and Species Found**
SP1	Gregory Crossing to Carl Creek Crossing	Spotlight	*7 Pteropus scapulatus* *1 Macropus agilis* *1Felis catus*
SP2	Gregory River 1.5 km N of crossing	Spotlight	*2 Macropus agilis* *4 Sus scrofa*
SP3	Gregory River 2.0 km S of crossing	Spotlight	*8 Macropus agilis* *1 Lagorchestes conspicillatus*
SP4	Gregory Floodplain west of Lloyds Camp	Spotlight	*9 Macropus rufus* *1 Macropus agilis* *2 Onychogalea unguifera* *6 Sus scrofa* *1 Canis lupus dingo*
SP5	OShannassey River near crossing	Spotlight	*2 Macropus agilis*
SP6	Gregory River Terraces	Spotlight	*1 Macropus agilis* *2 Macropus rufus* *1 Macropus antilopinus*
SP7	D Site to E Site	Spotlight	*1 Macropus robustus erubescens* *1 Petrogale purpurcollis*
SP8	Louie Creek Cave 1	Spotlight	*31 Myotis macropus* *16 Taphozous georgiana* *6 Vespedeles finlaysoni*
SP9	Louie Creek Cave 2	Spotlight	*77 Hipposideros ater* *8 Rhinonicteris aurantius* *7 Taphozous georgiana*
SP10	Louie Creek Cave 3	Spotlight	*13 Taphozous georgiana* *4 Vespedeles finlaysoni*
SP11	Gregory River near Washing Machine	Spotlight	*4 Bos bubalis* *1 Macropus agilis*
SP12	Gregory Floodplain 3 km west of Lloyds Camp	Spotlight	*4 Macropus rufus* *1 Macropus agilis*
SP13	Gregory Floodplain near Verdon Creek	Spotlight	*7 Macropus rufus* *1 Macropus agilis* *2 Petrogale purpurcollis* *1 Canis lupus dingo*
SP14	Judiths Horizontalis	Spotlight	*1 Tachyglossus aculeatus* *3 Macropus robustus erubescens* *2 Petrogale purpurcollis* *1 Petrogale sp*
SP15	Gregory River 3 km upstream of crossing	Spotlight	*2 Macropus agilis*
SP16	Microsite Valley	Spotlight	*1 Macropus robustus erubescens* *1 Petrogale purpurcollis*
SP17	Cleft of Ages Valley	Spotlight	*1 Petrogale purpurcollis* *1 Tachyglossus aculeatus*

SP18	Godthelps Hill	Spotlight	*1 Macropus robustus erubescens* *1 Petrogale purpurcollis*
SP19	Hals Hill	Spotlight	*3 Macropus robustus erubescens*
SP20	Lilydale Mine and Ranges	Spotlight	*2 Macropus robustus erubescens* *1 Macropus rufus* *1 Tachyglossus aculeatus*
SP21	Lilydale Springs	Spotlight	*2 Petrogale purpurcollis* *1 Canis lupus dingo*
SP22	Louie Creek Cave 1	Spotlight	*13 Myotis macropus* *8 Taphozous georgiana* *4 Vespedeles finlaysoni*
SP23	Louie Creek Cave 2	Spotlight	*55 Hipposideros ater* *15 Taphozous georgiana* *1Chaerophon jobensis*
SP24	Louie Creek Cave 3	Spotlight	*4 Taphozous georgiana* *2 Vespedeles finlaysoni*
SP25	Lawn Hill Creek Adels Grove	Spotlight	*3 Macropus agilis* *1 Trichosurus vulpecula arnhemensis* *6 Sus scrofa*
SP26	Louie Creek Crossing Adels Grove	Spotlight	*2 Macropus agilis*
SP27	Louie Creek Valley entrance	Spotlight	*2 Macropus agilis* *1 Macropus robustus erubescens*
SP28	Louie Creek below Caves 1 and 2 and side valley	Spotlight	*3 Macropus agilis* *3 Sus scrofa*
SP29	Louie Creek valley near Cave 3	Spotlight	*2 Petrogale purpurcollis* *4 Sus scrofa*
SP30	Riversleigh/Lawn Hill Boundary	Spotlight	*3 Macropus rufus* *2 Macropus agilis* *2 Onychogalea unguifera* *6 Sus scrofa* *1 Canis lupus dingo*
Sp31	Adels Grove to Observation Hill	Spotlight	*2 Macropus agilis* *8 Sus scrofa*
Sp32	Island Stack	Spotlight	*5 Petropseudes dahli*
SP33	Indarri Lookout	Spotlight	*1 Petropseudes dahli* *4 Vespedeles findlaysoni*
SP34	Cabbage Tree Plain east of Lilydale Mine	Spotlight	*11 Macropus rufus*
SP35	Cabbage Tree Plain east of Louie Creek Gorge	Spotlight	*1 Macropus agilis* *2 Onychogalea unguifera* *6 Sus scrofa* *1 Canis lupus dingo*
SP36	Cabbage Tree Plain 4 km N of Lilydale Mine	Spotlight	*3 Macropus rufus* *2 Macropus agilis* *2 Lagorchestes conspicillatus* *4 Sus scrofa* *1 Canis lupus dingo*
SP37	Lawn Hill between Upper Gorge and Colless Creek	Spotlight	*1 Hydromys chrysogaster*
SP38	Colonel Light Cave and Grikefield	Spotlight	*1 Petrogale sp.* *29 Taphozous georgiana*
SP39	Colless Creek Valley	Spotlight	*3 Macropus agilis* *1 Tachyglossus aculeatus*
SP40	Lawn Hill Creek 2 km upstream Colless Ck junction	Spotlight	*2 Macropus agilis*
SP41	Widdalion Waterhole area	Spotlight	*2 Petrogale purpurcollis* *1 Tachyglossus aculeatus*
SP42	Constance Range 2 km N of park entrance	Spotlight	*3 Macropus robustus erubescens* *2 Petrogale purpurcollis* *2 Macropus agilis* *5 Sus scrofa*
SP43	Dry Gap valley	Spotlight	*1 Macropus robustus erubescens*

SP44	Middle to Upper Gorge Track	Spotlight	*Nil*
SP45	Boodjamulla Waterhole	Spotlight	*1 Macropus agilis*
SP46	Island Stack to Cascades	Spotlight	*1 Petropseudes dahli*
SP47	AL90 Valley	Spotlight	*2 Petrogale purpurcollis* *1 Macropus robustus erubescens*
SP48	Gag Plateau	Spotlight	*1 Petrogale purpurcollis*
SP49	Track from fence to Gag Plateau	Spotlight	*2 Macropus robustus erubescens* *1 Macropus agilis*
SP50	Verdon Rock	Spotlight	*1 Petrogale purpurcollis*

Site No	Location	Survey Type	Number and Species Found
SP1	Gregory Crossing to Carl Creek Crossing	Spotlight	*7 Pteropus scapulatus* *1 Macropus agilis* *1 Felis catus*
SP2	Gregory River 1.5 km N of crossing	Spotlight	*2 Macropus agilis* *4 Sus scrofa*
SP3	Gregory River 2.0 km S of crossing	Spotlight	*8 Macropus agilis* *1 Lagorchestes conspicillatus*
SP4	Gregory Floodplain west of Lloyds Camp	Spotlight	*9 Macropus rufus* *1 Macropus agilis* *2 Onychogalea unguifera* *6 Sus scrofa* *1 Canis lupus dingo*
SP5	OShannassey River near crossing	Spotlight	*2 Macropus agilis*
SP6	Gregory River Terraces	Spotlight	*1 Macropus agilis* *2 Macropus rufus* *1 Macropus antilopinus*
SP7	D Site to E Site	Spotlight	*1 Macropus robustus erubescens* *1 Petrogale purpurcollis*
SP8	Louie Creek Cave 1	Spotlight	*31 Myotis macropus* *16 Taphozous georgiana* *6 Vespedeles finlaysoni*
SP9	Louie Creek Cave 2	Spotlight	*77 Hipposideros ater* *8 Rhinonicteris aurantius* *7 Taphozous georgiana*
SP10	Louie Creek Cave 3	Spotlight	*13 Taphozous georgiana* *4 Vespedeles finlaysoni*
SP11	Gregory River near Washing Machine	Spotlight	*4 Bos bubalis* *1 Macropus agilis*
SP12	Gregory Floodplain 3 km west of Lloyds Camp	Spotlight	*4 Macropus rufus* *1 Macropus agilis*
SP13	Gregory Floodplain near Verdon Creek	Spotlight	*7 Macropus rufus* *1 Macropus agilis* *2 Petrogale purpurcollis* *1 Canis lupus dingo*
SP14	Judiths Horizontalis	Spotlight	*1 Tachyglossus aculeatus* *3 Macropus robustus erubescens* *2 Petrogale purpurcollis* *1 Petrogale sp*
SP15	Gregory River 3 km upstream of crossing	Spotlight	*2 Macropus agilis*
SP16	Microsite Valley	Spotlight	*1 Macropus robustus erubescens* *1 Petrogale purpurcollis*
SP17	Cleft of Ages Valley	Spotlight	*1 Petrogale purpurcollis* *1 Tachyglossus aculeatus*
SP18	Godthelps Hill	Spotlight	*1 Macropus robustus erubescens* *1 Petrogale purpurcollis*
SP19	Hals Hill	Spotlight	*3 Macropus robustus erubescens*
SP20	Lilydale Mine and Ranges	Spotlight	*2 Macropus robustus erubescens* *1 Macropus rufus* *1 Tachyglossus aculeatus*

SP21	Lilydale Springs	Spotlight	*2 Petrogale purpurcollis* *1 Canis lupus dingo*
SP22	Louie Creek Cave 1	Spotlight	*13 Myotis macropus* *8 Taphozous georgiana* *4 Vespedeles finlaysoni*
SP23	Louie Creek Cave 2	Spotlight	*55 Hipposideros ater* *15 Taphozous georgiana* *1 Chaerophon jobensis*
SP24	Louie Creek Cave 3	Spotlight	*4 Taphozous georgiana* *2 Vespedeles finlaysoni*
SP25	Lawn Hill Creek Adels Grove	Spotlight	*3 Macropus agilis* *1 Trichosurus vulpecula arnhemensis* *6 Sus scrofa*
SP26	Louie Creek Crossing Adels Grove	Spotlight	*2 Macropus agilis*
SP27	Louie Creek Valley entrance	Spotlight	*2 Macropus agilis* *1 Macropus robustus erubescens*
SP28	Louie Creek below Caves 1 and 2 and side valley	Spotlight	*3 Macropus agilis* *3 Sus scrofa*
SP29	Louie Creek valley near Cave 3	Spotlight	*2 Petrogale purpurcollis* *4 Sus scrofa*
SP30	Riversleigh/Lawn Hill Boundary	Spotlight	*3 Macropus rufus* *2 Macropus agilis* *2 Onychogalea unguifera* *6 Sus scrofa* *1 Canis lupus dingo*
Sp31	Adels Grove to Observation Hill	Spotlight	*2 Macropus agilis* *8 Sus scrofa*
Sp32	Island Stack	Spotlight	*5 Petropseudes dahli*
SP33	Indarri Lookout	Spotlight	*1 Petropseudes dahli* *4 Vespedeles findlaysoni*
SP34	Cabbage Tree Plain east of Lilydale Mine	Spotlight	*11 Macropus rufus*
SP35	Cabbage Tree Plain east of Louie Creek Gorge	Spotlight	*1 Macropus agilis* *2 Onychogalea unguifera* *6 Sus scrofa* *1 Canis lupus dingo*
SP36	Cabbage Tree Plain 4 km N of Lilydale Mine	Spotlight	*3 Macropus rufus* *2 Macropus agilis* *2 Lagorchestes conspicillatus* *4 Sus scrofa* *1 Canis lupus dingo*
SP37	Lawn Hill between Upper Gorge and Colless Creek	Spotlight	*1 Hydromys chrysogaster*
SP38	Colonel Light Cave and Grikefield	Spotlight	*1 Petrogale sp.* *29 Taphozous georgiana*
SP39	Colless Creek Valley	Spotlight	*3 Macropus agilis* *1 Tachyglossus aculeatus*
SP40	Lawn Hill Creek 2 km upstream Colless Ck junction	Spotlight	*2 Macropus agilis*
SP41	Widdalion Waterhole area	Spotlight	*2 Petrogale purpurcollis* *1 Tachyglossus aculeatus*
SP42	Constance Range 2 km N of park entrance	Spotlight	*3 Macropus robustus erubescens* *2 Petrogale purpurcollis* *2 Macropus agilis* *5 Sus scrofa*
SP43	Dry Gap valley	Spotlight	*1 Macropus robustus erubescens*
SP44	Middle to Upper Gorge Track	Spotlight	*Nil*
SP45	Boodjamulla Waterhole	Spotlight	*1 Macropus agilis*
SP46	Island Stack to Cascades	Spotlight	*1 Petropseudes dahli*
SP47	AL90 Valley	Spotlight	*2 Petrogale purpurcollis* *1 Macropus robustus erubescens*

APPENDIX I

Site No	Location	Survey Type	Number and Species Found
A1	Gregory River Crossing	Anabat	*Nyctophilus walkeri* *Chalinolobus gouldii* *Myotis macropus*
A2	Carl Creek Road crossing	Anabat	*Nyctophilus walkeri* *Myotis macropus*
A3	OShannassey River crossing	Anabat	*Nyctophilus walkeri*
A4	Gregory River near terraces	Anabat	*Chalinolobus gouldii* *Myotis macropus*
A5	Gregory River near Lloyds Camp	Anabat	*Chalinolobus gouldii* *Myotis macropus* *Nyctophilus walkeri*
A6	Louie Creek Cave 1	Anabat	*Myotis macropus* *Taphozous georgianus* *Vespadelus finlaysoni*
A7	Louie Creek Cave 2	Anabat	*Taphozous georgianus* *Hipposideros ater* *Chaerophon jobensis*
A8	Louie Creek Cave 3	Anabat	*Taphozous georgiana* *Vespadelus finlaysoni*
A9	Gregory River near Washing machine	Anabat	*Nyctophilus walkeri*
A10	Verdon Creek	Anabat	*Scotorepens greyi*
A11	Louie Creek Cave 1	Anabat	*Taphozous georgianus* *Vespadelus finlaysoni*
A12	Louie Creek Cave 2	Anabat	*Taphozous georgianus* *Hipposideros ater*
A13	Louie Creek Cave 3	Anabat	*Taphozous georgianus*
A14	Gregory River Crossing	Anabat	*Nyctophilus walkeri* *Myotis macropus* *Chalinolobus gouldii*
A15	Carl Creek Road crossing	Anabat	*Taphozous flaviventris* *Nyctophilus walkeri*
A16	Lilydale Mine	Anabat	*Nil*
A17	Verdon Rock	Anabat	*Scotorepens greyi*
A18	Forbes Inferno	Anabat	*Taphozous georgianus* *Vespadelus finlaysoni*
A19	Verdon Creek	Anabat	*Scotorepens greyi* *Hipposideros ater*
A20	Lilydale Springs	Anabat	*Taphozous georgianus*
A21	Louie Creek Cave 1	Anabat	*Myotis macropus* *Taphozous georgianus* *Vespadelus finlaysoni*
A22	Louie Creek Cave 2	Anabat	*Taphozous georgianus* *Hipposideros ater* *Rhinonicteris aurantia* *Chaerophon jobensis*
A23	Louie Creek Cave 3	Anabat	*Taphozous georgiana* *Vespadelus finlaysoni*
A24	Louie Creek Valley entrance	Anabat	*Taphozous georgianus* *Hipposideros ater*
A25	Louie Creek lower Road Crossing	Anabat	*Taphozous georgiana*
A26	Lawn Hill Creek Adels Grove	Anabat	*Nyctophilus walkeri* *Nyctophilus gouldii/geoffroyi*
A27	Lawn Hill Creek Boodjamulla Waterhole	Anabat	*Chalinolobus gouldii* *Myotis macropus*
A28	Lawn Hill Creek Indarri Falls	Anabat	*Myotis macropus*
A29	Lawn Hill Creek Cascades	Anabat	*Myotis macropus*
A30	Lawn Hill Creek Upper Gorge	Anabat	*Myotis macropus*

A31	Louie Creek Adels Grove Crossing	Anabat	*Myotis macropus* *Nyctophilus gouldii/geoffroyi*
A32	Louie Creek Cave 1	Anabat	*Myotis macropus* *Taphozous georgianus* *Vespadelus finlaysoni*
A33	Louie Creek Cave 2	Anabat	*Taphozous georgiana* *Hipposideros ater* *Vespadelus finlaysoni*
A34	Louie Creek Cave 3	Anabat	*Taphozous georgianus*
A35	Colonel Light Cave	Anabat	*Taphozous georgianus* *Vespadelus finlaysoni*
A36	Colless Creek below Grikefield	Anabat	*Vespadelus finlaysoni*
A37	Widdalion Waterhole	Anabat	*Vespadelus finlaysoni*
A38	Widdalion Creek	Anabat	*Scotorepens greyi*
A39	Lawn Hill Constance Range Track	Anabat	*Vespadelus finlaysoni*
A40	Louie Creek Cave 1	Anabat	*Myotis macropus* *Taphozous georgianus* *Vespadelus finlaysoni*
A41	Louie Creek Cave 2	Anabat	*Taphozous georgianus* *Hipposideros ater* *Vespedeles finlaysoni* *Chaerophon jobensis*
A42	Louie Creek Cave 3	Anabat	*Taphozous georgianus* *Vespadelus finlaysoni*
A43	Godthelps Hill	Anabat	*Nil*
A44	Hals Hill	Anabat	*Nil*
A45	Louie Creek Cave 1	Anabat	*Myotis macropus* *Taphozous georgianus* *Vespadelus finlaysoni*
A46	Louie Creek Cave 2	Anabat	*Myotis macropus* *Taphozous georgianus* *Vespadelus finlaysoni* *Hipposideros ater*
A47	Louie Creek Cave 3	Anabat	*Vespadelus finlaysoni* *Taphozous georgianus*

Site No	Location	Survey Type	Number and Species Found
HT1	Lawn Hill Creek Adels Grove	Harp Trap	*27 Nyctophilus walkeri* *4 Myotis macropus* *2 Nyctophilus geoffroyi*
HT2	Louie Creek Adels Grove	Harp Trap	*16 Myotis macropus* *4 Scotorepens greyi* *2 Nyctophilus bifax* *1 Nyctophilus geoffroyi* *1 Chalinolobus gouldii*
HT3	Louie Creek Lower Road Crossing	Harp Trap	*30 Myotis macropus* *2 Scotorepens greyi* *1 Vespadelus finlaysoni*
HT4	Louie Creek below Caves 1 and 2	Harp Trap	*10 Myotis macropus* *11 Nyctophilus walkeri* *1 Nyctophilus geoffroyi* *1 Chaerephon jobensis*
HT5	Gregory River Crossing	Harp Trap	*2 Chalinolobus gouldii* *29 Myotis macropus* *38 Nyctophilus walkeri* *2 Nyctophilus geoffroyi* *2 Nyctophilus bifax*
HT6	Carl Creek Road Crossing	Harp Trap	*3 Myotis macropus* *4 Nyctophilus walkeri* *1 Hipposideros stenotis* *1 Chalinolobus gouldii*

APPENDIX I

HT7	OShannassey River crossing	Harp Trap	3 *Myotis macropus* 6 *Nyctophilus walkeri* 2 *Chalinolobus gouldii*
HT8	Lawn Hill Creek Boodjamulla Waterhole	Harp Trap	9 *Myotis macropus* 21 *Nyctophilus walkeri*
HT9	Lawn Hill Creek Cascades	Harp Trap	7 *Myotis macropus* 17 *Nyctophilus walkeri* 2 *Chalinolobus gouldii*
HT10	Dam near Verdon Rock	Harp Trap	8 *Scotorepens greyi* 4 *Hipposideros ater*
HT11	Verdon Creek near Road Crossing	Harp Trap	5 *Scotorepens greyi* 4 *Hipposideros ater* 1 *Vespadelus finlaysoni*